First record of the Gnetales in Australia: *Gnetum gnemon* L. (Gnetaceae) on Badu and Mua islands, Torres Strait, Queensland

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Summary

Fell, D.G., Stanton, D.J., Williams, D., Loban, F., Nona, F., Stow, T., Wigness, J., Manas E., and Uiduldam G. (2015). First record of the Gnetales in Australia: *Gnetum gnemon* L. (Gnetaceae) on Badu and Mua Islands, Torres Strait, Queensland. ***Austrobaileya* 9(3): 421–430**. The gymnosperm order Gnetales is reported for the first time in Australia, from specimens of *Gnetum gnemon* collected on two continental islands in Torres Strait, Queensland. The distribution, habitat, ecology and local conservation status of the species are discussed, and its origins in Torres Strait are considered with reference to biogeographic and anthropogenic factors.

Key Words: Gnetaceae, *Gnetum gnemon*, Australia flora, Queensland flora, Badu Island, Mua Island, Torres Strait

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Introduction

Gnetum L. is the sole genus within the family Gnetaceae and order Gnetales of the gymnosperms. The genus consists of about 40 species with 10 species in South America, one in tropical West Africa, and 20–25 species in tropical and subtropical Asia (Markgraf 1929, 1977; Maheshwari & Vasil 1961; Verheij & Sukendar, 1991; Carlquist 1994, 1996; Price 1996; Wonn & Renner 2006, Hou *et al.* 2015). The origins and evolutionary relationships of the gnetophytes are considered as central toward understanding the origin of flowers and seed plant evolution (Markgraf 1929; Chamberlain 1935; Price 1996; Hansen *et al.* 1999; Winter *et al.* 1999; Manner & Eleivich 2006). Recent genetic studies now recognise that gnetophytes are more closely related to conifers than to angiosperms (Hansen *et al.* 1999; Winter *et al.* 1999; Becker *et al.* 2000), and that the major lineages of *Gnetum* diverged in the Late Cretaceous (Hou *et al.* 2015).

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Gnetum gnemon L. has a wide distribution in Malesia and the Western Pacific and is native to Indonesia, Papua New Guinea, the Solomons, and Vanuatu (Verheij & Sukendar 1991; Manner & Eleivich 2006; Wonn & Renner 2006; Bourke 2010). In Papua New Guinea it occurs in the Morobe, Eastern Highlands, Western Highlands, Central, East Sepik, Sandaun (West Sepik), Manus Island, New Ireland, Western, Bougainville, New Britain, Madang, Milne Bay, and Gulf Provinces (Conn & Damas 2006). It is previously known in Australia only from cultivated trees in the vicinity of Darwin (Atlas of Living Australia, 2012; I. Cowie *pers. comm.*, November 2012).

Gnetum gnemon is a dioecious evergreen tree 15–30 m in height in the canopy or subcanopy with a trunk diameter at breast height to 40 cm (Peekel 1984; Conn & Damas 2006; Manner & Eleivich 2006). The trunk is smooth and cylindrical with prominent raised swollen bands (100–300 mm apart) caused by the growth and fall of the opposite and symmetrical branches (Conn & Damas 2006). Leaves are simple and opposite, elliptic, lanceolate or oblong-oval, 15–25 cm long and 5–9 cm wide (Manner & Eleivich 2006). As a gymnosperm, *Gnetum* does not have true

flowers; the cones or strobili are presented at the tip of a slender stem or axis (Chamberlain 1935; Manner & Eleivich 2006). It has yellow single-seeded fruits which turn purplered or orangered at maturity (Maheshwari & Vasil 1961; Manner & Eleivich 2006), ripening between September and December (Bourke *et al.* 2004).

Across its Asian, Malesian and Western Pacific range the genus *Gnetum* is known from tropical rainforest up to 1,700 m with rainfall of 750–5,000 mm/year (Manner & Eleivich 2006). It occurs in primary and secondary vegetation, with cultivated trees commonly found in home orchards and subsistence gardens.

Wild and cultivated *Gnetum gnemon* is an important natural resource in many parts of Asia, Malesia and the Pacific where it occurs. Documented uses include: food (leaves for wrapping food items, young cones and leaves cooked with meat for flavoring; seeds ground into a flour for fried flat cakes; flowers (stroboli) eaten; young fruits eaten raw or cooked; timber (poles for house construction, tool handles, burned for fuel, and pulped for papermaking); stem bark fibre (string bags, ropes, bowstring on musical instruments, construction of fishing lines and fishnets, assembling arrowheads and arrowshafts); agroforestry and rehabilitation (intercropping for rambutan and breadfruit, trellis for *Dioscorea* yams, improving soil fertility, windbreaks, boundary markers) (Henderson & Hancock 1989; Verheij & Sukendar 1991; Ohtsuksa 1983; Peekel 1984; Salim *et al.* 2002; Walter & Sam 2002; Manner & Eleivich 2006; Quartermain & Tomi 2010). Extracts derived from *Gnetum* are reported useful as health supplements (Kato *et al.* 2009) and the nuts form an important home industry throughout Indonesia (Cadiz & Florido 2001).

In Papua New Guinea it is an important wild and cultivated food plant in many locations (Powell 1976; Bourke 2004) and known in Tok pisin as '*Tulip*' (two leaves) (French 1986). The Gidra people of the Oriomo River area of southwest Papua New Guinea adjacent to Torres Strait, eat the fruits and leaves (Ohtsuka 1983), and the leaves and fruit are identified as a source of protein across the nation (Cordon 1970). Cultivation of trees is achieved by propagating seed and/or from cuttings (French 1986). In the Kiunga area of Western Province the bark is used to make the fibre for string bags and other products and it is also cultivated as a food plant (leaves) in Daru (Western Province) (B. Waterhouse *pers. comm.*, April 2014).

We report on the occurrence of *Gnetum gnemon* on two islands in Torres Strait, Queensland, thus recognizing the gymnosperm order Gnetales for the first time from Australia. The distribution, habitat and ecology of the species at these localities are discussed together with an assessment of its local conservation status. Its origins in Torres Strait are considered with reference to biogeographic and anthropogenic factors.

Materials and methods

A survey of the vegetation of the Torres Strait Islands, Queensland, Australia, was carried out in 2007 (Stanton *et al.* 2009). The survey's primary objective was to map vegetation communities at a scale of 1:25,000 and Regional Ecosystems at a scale of 1:50,000, and was supplemented by floristic inventory and collections of voucher specimens for Australian herbaria. Additional surveys on the Badu and Mua islands between 2009 and 2015 have been carried out as part of a biodiversity management planning program through the Land and Sea Management Unit of the Torres Strait Regional Authority (3D Environmental 2011a, 2011b; Gynther *et al.* 2014; Reis *et al.* 2015).

Collections of *Gnetum gnemon* were made at Badu Island in October 2007 (*Fell 10206 & Stanton*) (**Fig.** 1) and on Mua Island in April 2011 (*Fell 10803 & Stanton*) (**Fig. 2**), with further confirmed observations on Mua in March 2014 and on Badu in May 2015 (Fell pers. obs.). Voucher specimens are lodged with the Queensland Herbarium (BRI) with duplicates to the Australian Tropical Herbarium (CNS).

Fig. 1. Leaves of ***Gnetum gnemon*** on Badu Island (*Fell 10206 & Stanton*). Photo: D.G. Fell.

Results and discussion

Gnetum gnemon in Torres Strait

Badu Island

Badu Island is situated approximately midway between the tip of Cape York Peninsula and mainland New Guinea, and belongs to the Near Western Group of Torres Strait Islands. It is a continental island of 10,467 ha, centred at 10° 07' S, 142° 09' E and located around 92 km south of the Papua New Guinea (PNG) coastline and 70 km NW of Cape York (**Map 1**). The island is the homeland of the Badulgal people with a population of 784 people as at the 2011 census (Australian Bureau of Statistics 2012).

The coarse grained Badu granite dominates the landscape, forming the island's rugged interior of low rocky hillocks with massive granite boulders. Granite basement rock is overlain on its margins by younger unconsolidated deposits including alluvial deposits and extensive dune fields of varying age and geomorphic expression (Willmott & Powell 1977; Garnett & Jackes 1983; 3D Environmental 2011a).

A total of 49 vegetation communities within 20 broad vegetation groups and 32 Regional Ecosystems are recognised across the island, within which 592 plant species have been recorded. The flora comprises 560 native species with 17 ferns, one cycad, one conifer and 572 flowering plants (3D Environmental 2011a).

Mua Island

Mua (also known as Moa) Island lies adjacent and immediately to the east-south east of Badu, being separated by a narrow (2.5 km wide) channel. Situated approximately 55 km

north of the tip of Cape York, Queensland and 94 km south of the New Guinea mainland (**Map 1**), it has a total area of 17,001 ha, and is the second largest island in Torres Strait. There are two Torres Strait Islander communities on the island: at Kubin and St Pauls, which had populations of 163 and 258 respectively as at the 2011 census (Australian Bureau of Statistics 2012).

Mua is formed on continental igneous basement rocks and is topographically diverse, dominated by the high point of Banks Peak in the north-east, rising to 376 m. A rugged east and south facing coastline features rocky coastal headlands, and an expansive coastal plain forms a broad enclave behind the island's north-eastern coastline. Vegetation is diverse with a total of 62 vegetation communities occurring within 23 broad vegetation groups and 44 regional ecosystems. The flora is the richest in the Torres Strait region with 609 native species, comprising 19 ferns, one cycad, two conifers and 654 flowering plants (3D Environmental 2012a).

Fig. 2. Upland habitat of ***Gnetum gnemon*** on Banks Peak, Mua Island. Photo: D.J. Stanton.

Local Habitat & Ecology

In Torres Strait *Gnetum* occurs in poorly drained lowland swamp forest (Badu), lowland riparian rainforest (Mua), and on steep granitic hillslopes in well-developed evergreen vineforest (Mua) (**Fig. 3**).

The Badu occurrence is within a closed (swamp) forest characterised by poorly drained soils which may be seasonally inundated. Typical canopy tree species are *Carallia brachiata* (Lour.) Merr., *Deplanchea tetraphylla* (R.Br.) F.Muell., *Lophostemon suaveolens* (Sol. ex Gaertn.) Peter G.Wilson

Fig. 3. Multi stemmed trunk of ***Gnetum gnemon*** in lowland riparian rainforest on Mua Island. Photo: D.G. Fell.

& J.T.Waterh., *Maranthes corymbosa* Blume, *Melaleuca dealbata* S.T. Blake and *Syzygium angophoroides* (F.Muell.) B.Hyland with a sharp ecotone to the surrounding woodland vegetation.

On Mua, *Gnetum* occurs in upland and lowland situations. Upland habitats are on the steep granite hillslopes and crests of Banks Peak, the highest topographic feature in Torres Strait. *Gnetum* was recorded between approximately 250–350 m altitude in evergreen notophyll vineforest and in wind sheared evergreen vinethicket (**Fig. 2**). The evergreen vineforests are developed on upper sheltered slopes where weathering of the granite has produced a well-drained and relatively fertile sandy loam soil (3D Environmental 2011b). The rainforest type is a unique and newly described ecosystem for Queensland, restricted to only a few mountain top locations in Torres Strait (3D Environmental 2009). The canopy height ranges from 23 m to 35 m with dominants including *Acmenosperma claviflorum* (Roxb.) Kausel., *Anthocarapa nitidula* (Benth.) T.D.Penn. ex Mabb., *Calophyllum sil* Lauterb., *Manilkara kanosiensis* H.J.Lan & B.Meeuse, *Sterculia shillinglawii* F.Muell. subsp. *shillinglawii* and *Syzygium beuttnerianum* (K.Schum.) Nied. *Gnetum* habitat on the steep southern slopes of the peak features a wind sheared canopy of *Acmenosperma claviflorum*, *Calophyllum sil*, *Podocarpus grayae* De Laub. *Licuala ramsayi* var. *tuckeri* Barfod & Dowe and *Pandanus zea* H.St. John. Riparian rainforest on alluvial sands and silts constitute *Gnetum* lowland habitat on Mua. Characteristic canopy species are *Buchanania arborescens* (Blume) Blume, *Horsfieldia australiana* S.T.Blake, *Maranthes corymbosa* Blume, *Syzygium angophoroides* and *S.bamagense* B.Hyland.

No uses are documented or known for *Gnetum gnemon* in the Torres Strait. Specimens were shown to Land and Sea Rangers during our visits to Badu in November 2007, November 2010 and May 2015, and on Mua in March 2011 and March 2014. They did not recognise the plant, and stated that they had no name or use for it (D. Williams *pers. comm*., 2015; T. Stow *pers. comm*., 2007; J. Wigness *pers. comm*., 2011).

Natural or translocated?

Some plants and their populations in Torres Strait are a reflection of natural biogeographic distributions, whereas others are anthropogenic and may indicate the influence of people as dispersal agents (Denham 2008; Denham *et al*. 2009; McNiven 2008).

The accepted hypothesis that the pantropical range of *Gnetum* reflects a Gondwanan history was established by Markgraf (1929). However, Wonn & Renner (2006) consider that its present range follows a more recent radiation in the Malesian region, and therefore is not Gondwanan. Using analysis of fossil-calibrated molecular-clocks, these authors investigated *Gnetum* lineages now found in Africa, South America and Southeast Asia with results suggesting the influence of ancient long-distance dispersal of

seeds across seawater. Further, its distribution throughout Asia is thought to have occurred during radiation through Malesia where opportunities for overland seed dispersal coincided with times of low sea levels (Wonn & Renner 2006).

Torres Strait was formed by rising sea levels in the Holocene (*c.* 8000–6500 years before present) that inundated the Arafura Plain, a low-lying land bridge that connected Australia and New Guinea for much of recent geological history (Jennings 1972; Woodroffe *et al.* 2000). Given the occurrence of *G. gnemon* in neighboring areas of central-southern New Guinea, it is likely the Torres Strait records are refugial populations that reflect its biogeographic distribution across the Malesian region.

However, the potential for the taxon to have been introduced into Torres Strait by human vectors should not be discounted. The species is widely cultivated across its range, including in New Guinea, and hence it is possible that it was translocated to the islands. Movements of human populations and trade between New Guinea and Torres Strait have greatly influenced the distribution patterns of a number of important tropical crop plants and has influenced cultivation practices in the region (Haddon 1935; Barrau 1963; Harris 1977; Barham 2000; Denham 2008; Denham *et al.* 2009; McNiven *et al.* 2006; McNiven 2008). Furthermore, the impact of Torres Strait islanders upon their pre-contact surroundings included the introduction of new plant species from other islands (Shnukal 2004; McNiven 2008), a practice that is ongoing in contemporary culture. The fact that local people do not have a local name or a use for the plant does not mean that it was not used in the past.

Conservation Status

Across the majority of its range *Gnetum gnemon* is a common tree species in the wild that is also widely cultivated throughout Malesia. In Torres Strait, a conservative estimate of its population size on Badu is 500–1000 individuals within an area of available habitat of < 200 ha. Surveys carried out by the authors in 2007, 2009, 2011, 2014 and 2015 assessed the condition of the habitat as good, being free of weeds although diggings by feral pigs (*Sus scrofa*) were observed throughout the habitat. The even age of the canopy and the species composition together with evidence of old charred stumps indicate that the habitat is transitional and subject to past burning. Invasive weeds such as Singapore daisy (*Sphagneticola trilobata* (L.) Pruski), praxelis (*Praxelis clematidea* R.M.King & H.Rob.), annual mission grass (*Pennisetum pedicellatum* Trin. subsp. *pedicellatum*) and leucaena (*Leucaena leucocephala* (Lam.) de Wit) occur on the islands, but are mostly associated with habitation and along roadsides. Singapore daisy has successfully invaded degraded swamp forests within and on the margins of the Badu community and is considered a serious threat to these habitats across the island.

Resilience to fire of *Gnetum gnemon* is not documented; however, its mesic habitat is likely to be sensitive to fire. Fire has been an ongoing influence on the island's vegetation, and fire management is an increasing focus of the Land and Sea Ranger program (3D Environmental 2012a, 2012b). Given the small population size and highly localised occurrence, there is a risk of stochastic extinction of the species on this island.

The upland rainforest habitat of the Mua population is similarly remote and inaccessible, and no known direct threats are evident. Population size is not known; however, the spatial extent of the forest type is mapped as < 477 ha (Stanton *et al.* 2009). While numerous weeds occur on the island they are limited to the margins of the island communities Kubin and St Pauls and along some major tracks and roads. The undisturbed and remote nature of the upland habitat suggests that there would appear to be a very low risk of stochastic extinction of the population. Its lowland occurrence on Mua occupies approximately 20 ha within a linear band of riparian rainforest located three kilometres from the coast. The ecotone to adjacent *Corymbia* and *Melaleuca* grassy woodland vegetation is sharp and controlled

by seasonal burning practices. Weeds such as Brazilian joyweed (*Alternanthera brasiliana* (L.) Kuntze) and leucaena occur nearby. Weed incursions, and inappropriate fire management which erode fire sensitive riparian margins, represent potentially threatening processes to the integrity of the lowland *Gnetum* habitat.

Integration of further ecological and genetic studies are necessary to better understand the conservation and management requirements of *Gnetum gnemon* in Torres Strait. Future assessments on the conservation values of *Gnetum gnemon* in Torres Strait should acknowledge that conservation of peripheral populations is dependent upon the genetic divergence from other conspecific populations, and may be beneficial to the protection of the evolutionary process (Lesica & Allendorf 1995).

It is feasible that additional populations occur on Badu and Mua and further field assessments are required to better understand the species ecology in terms of distribution, population size, phenology, recruitment, and to investigate cultural values. Similar focus is also required for other additions to the Australia flora recently recorded in Torres Strait namely *Cycas papuana* F.Muell. and *Manilkara kanosienisis* H.J.Lan & B.Meeuse (Fell in prep.) as well as other highly disjunct species recorded in the region (Fell & Stanton 2011). Such studies are achievable with the support and involvement of traditional landowners and their representative bodies and the Torres Strait Regional Authority Land and Sea Management Unit.

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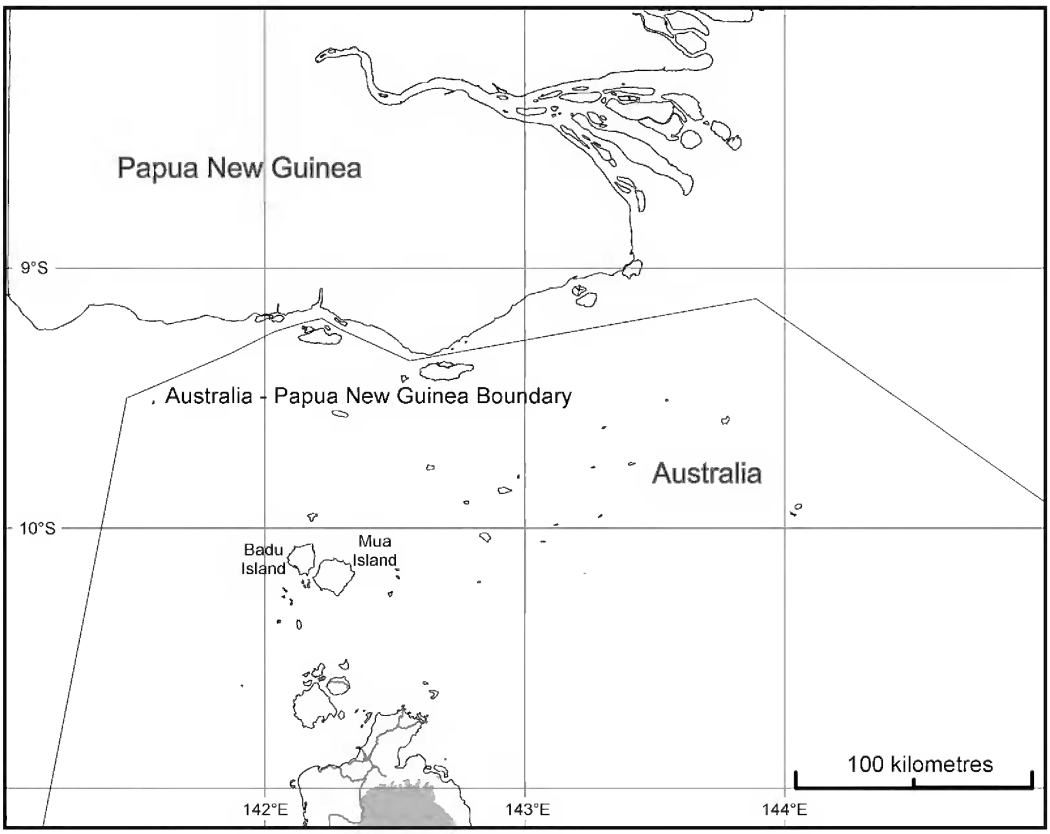

Map 1. Position of Badu and Mua islands in Torres Strait indicating position between Papua New Guinea and mainland Australia.